# Numerical Modeling to Study the Impact of Pore Characteristics on the Electric Breakdown of Rock for Plasma Pulse Geo Drilling (PPGD)



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# Numerical Modeling to Study the Impact of Pore Characteristics on the Electric Breakdown of Rock for Plasma Pulse Geo Drilling (PPGD)

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Reducing the cost of drilling is crucial to economically extract deep geothermal energy as drilling costs can reach up to 70% of the total investment budget (Tester et al. 2006). Unfortunately, traditional mechanical rotary drilling is often far too expensive to enable economical geothermal energy extraction from many deep geologic settings due to the amount of energy rotary drilling requires and due to its significant drill bit wear, causing long, unproductive tripping times to exchange worn drill heads (Schiegg et al. 2015). To reduce deep geothermal drilling costs, novel drilling technologies are required, such as Plasma Pulse Geo Drilling (PPGD) as well as thermal spallation, laser, and microwave drilling, to name a few (Woskov et al. 2014; Buckstegge et al. 2016; Vogler et al. 2020; Walsh et al. 2020).

PPGD is a so-called contact-less drilling technology that uses high-voltage electricity pulses >200 kV that last for ~2 microseconds to fracture the rock, thereby drilling without mechanical abrasion, reducing/eliminating costly, unproductive tripping times and requiring less energy to break the rock than rotary drilling. Experimentally, Anders et al. 2017 found that PPGD is ~17% cheaper than mechanical rotary drilling. Analytical studies by Rodland 2012 and Schiegg et al. 2015 suggested that further research could possibly reduce PPGD drilling costs by as much as ~90% of current mechanical rotary drilling costs. Nonetheless, the fundamental physics that underlies the PPGD process is still poorly understood, and the feasibility of PPGD under deep wellbore conditions requires further investigations. (Zhu et al. 2021) investigated numerically how the local electric breakdown in pores can lead to electric breakdown occurrence across the entire rock sample. Numerically, Ezzat et al. 2021 found that the plasma pressure generated due to the localized electric breakdown in rock pores is high enough to induce rock fracturing for specific conditions, resulting in drilling success.

Here, we present our preliminary numerical modeling results concerning the influence of rock pore characteristics, such as pore fluid, shape, and size on the localized electric breakdown of rock. Our goal is to eventually use these results to further increase the efficiency, and thus, further reduce the costs, of PPGD. Our results show that PPGD is facilitated if the rock pores are filled with a gas and not with water, which is consistent with the experimental findings of Lisitsyn et al. 1998 and Inoue et al. 1999. Also, our results suggest that larger pore sizes and smaller pore pressures are more favorable for PPGD. These findings are valid until ~1 MPa pore pressure. To extend our model to cover higher pressure ranges, further physical lab experiments are required that investigate the electric breakdown of air at high gas pressures >1 MPa.

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